5.—DIOPSIDIZATION AND HORNBLENDIZATION—IMPORTANT METASOMATIC PHENOMENA IN THE BASIC SCHISTS NEAR SOUTHERN CROSS, WESTERN AUSTRALIA

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ABSTRACT.

Amphibole-plagioclase schists are strongly marked by irregular transgressive diopsidic veins due to calcium metasomatism. Some of the veins (which are normally about 1½ inches wide) are almost pure diopside, but others may contain zones of one or more of the minerals grossularite, epidote, calcite and quartz set within an outer zone of diopside.

Metasomatic hornblendites are associated with many veins of diopside as narrow selvages to the diopside veins. The hornblendic rock has developed as a form of " basic front " in that ferromagnesian elements, expelled during calcium metasomatism, have been fixed in the surrounding rocks.

In areas where original bedding planes of sediments or original lava flows are almost obliterated by metamorphism, zones of considerable linear extent, in which diopsidization is prominent, could be readily mistaken for interbedded calcium-rich sediments. The cause of restriction of diopsidization to narrow bands within certain zones is not yet fully understood. The calcium-rich emanations necessary for the diopsidization and related phenomena are thought to have been expelled during widespread alkali metasomatism of basic lavas and sediments.

INTRODUCTION.

While carrying out petrological investigations on about 10,000 feet of diamond drill cores from Nevoria Gold Mine, the writer has been very impressed by the abundant evidence of the role of metasomatism in both ore bodies and country rocks. The following minerals occur as some of the more important products of metasomatism :—pyrrhotite after magnetite in metajaspilite, grunerite after magnetite in metajaspilite, diopside and hedenbergite after amphibole in both amphibole schist and metajaspilite, hornblende after actinolite and plagioclase in amphibole schist and metajaspilite, and anthophyllite after grunerite in amphibole schist. It is the aim of this paper to give a brief preliminary description of the two related phenomena of " diopsidization " and " hornblendization." A more detailed discussion of these, and related phenomena will be undertaken when a series of chemical analyses has been completed.

Nevoria is located 30 miles S.S.E. of Southern Cross in a belt of Pre-Cambrian metamorphosed basic lavas, ferriferous chemical sediments, tuffs and associated rocks which are surrounded by large tracts of granite and granitized lavas and sediments. Most of the rocks appear to belong to the cordierite-anthophyllite subfacies of the amphibolite metamorphic facies (using the nomenclature of Turner and Verhoogen, 1951).

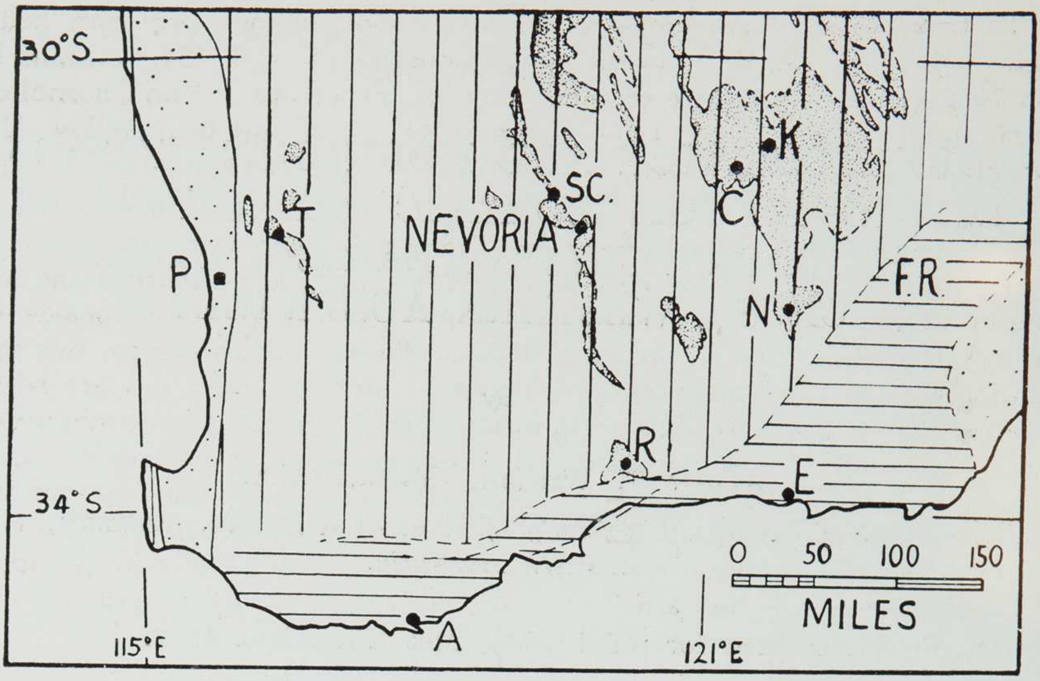

Fig. 1.

Sketch map of south-western Australia to show location of Nevoria. Vertical ruling = Pre-Cambrian granite and gneiss of Central Province; closely stippled belts are mostly Pre-Cambrian basic rocks and sediments of Central Province; horizontal ruling = Pre-Cambrian gneiss and granite of South Coast Province, together with fault blocks of (?) Late Proterozoic sediments; open stippling = mostly Mesozoic and later sediments; P = Perth, T = Toodyay; SC = Southern Cross; K = Kalgoorlie; C = Coolgardie; N = Norseman; FR = Fraser Range; R = Ravensthorpe; E = Esperance; A = Abany.

DESCRIPTION.

Amphibole-plagioclase schists (mostly metamorphosed basic lavas and tuffs) are conspicuously marked in places by diopsidic veins some of which transgress, and others which run parallel to the schistosity. The veins (commonly about 1½ inches wide) are metasomatic, as shown, in many cases, by the attitude of the undisturbed bedding or foliation on both sides of, and sometimes within, irregularly shaped diopsidic veins.

For the purposes of this paper the terms "*diopsidization*" and "*hornblendization*" have been proposed. They are analogous to such terms as albitization and analcitization, and are here used for the phenomena whereby diopside or hornblende (respectively) is produced in a rock by metasomatism.

During the study of the bore cores it has been found practicable to recognize macroscopically four main diopside-hornblende metasomatic assemblages. Each assemblage has been studied in considerable detail in thin section but in this preliminary paper only the most significant features are outlined. The four main assemblages are as follows :—

1. Diopside.
2. Diopside enclosing variable amounts of grossularite, epidote, calcite and quartz, the whole enclosed within a prominent but narrow zone of hornblende.
3. Hornblende enclosing diopside, which in turn encloses a zone of calcite.
4. Hornblende enclosing diopside, which in turn encloses a zone of calcite and lenticles of pyrrhotite and chalcopyrite.

In these assemblages diopside contains about 35 mol. per cent. hedenbergite (γ = 1·719, Z $\wedge$ c = 43°) ; grossularite (N = 1·754) contains less than 20 per cent. admixture of other garnet " molecules " ; and hornblende is a common variety (γ = 1·680, Z $\wedge$ c = 20°, X = pale fawn-yellow, Y = fawn-green, Z = bluish green).

ASSEMBLAGE 1.

Diopside occurring with accessory zoisite, quartz and calcite is the most abundant assemblage. It occurs in veins in amphibole schists of considerable variety of composition. Veins may run parallel to the schistosity, but more commonly form grotesquely shaped masses which may enclose relict patches of amphibole schist. In this assemblage the grain size of the diopside is commonly 1·5 mm. diameter and individual veins rarely exceed 20 mm. in true thickness. The average grain size of the minerals of the replaced rock is about 0·5 mm. diameter. Hornblende enrichment of the schist at the contacts with the diopside is always present, but rarely sufficient to appear in hand specimen as the bold dark grey selvage so characteristic of more intense calcium metasomatism. (Plate 1, fig. 1).

ASSEMBLAGE 2.

Veins made up mainly of diopside and grossularite are not plentiful, but have been observed in association with all types of amphibole schist at Nevoria. In the typical vein shown in Plate 1, fig. 2, a narrow but prominent hornblende zone encloses a well-marked diopside zone. This, in turn, encloses a zone of grossularite, and this encloses poorly defined zones or lenses of some or all of the minerals, epidote, calcite and quartz. In hand specimen hornblende appears dark greenish grey, diopside is greyish green, grossularite is pinkish fawn, epidote is greasy yellowish green, calcite is white, and quartz is colourless. The grain size of all the minerals usually exceeds 1·5 mm. in cross section, and the veins themselves are commonly 20–30 mm. in true thickness. (Plate 1, fig. 2).

ASSEMBLAGE 3.

Other than the " pure " diopside veins, this is the most common type of metasomatic vein at Nevoria. It is characterized by broad hornblendite zones outside the diopside, and a broad calcite zone as the core. Although the more ferriferous amphibole schists (*e.g.*, anthophyllite—, and grunerite-bearing schists) often carry such veins, they less frequently occur in normal hornblende schists. The grain size of the hornblende, diopside and calcite is commonly 4 mm. in cross section, and contrasts markedly with the small acicular needles of anthophyllite, grunerite and actinolite in the schists. (Plate 1, fig. 3).

ASSEMBLAGE 4.

This assemblage is characterized by the presence of pyrrhotite and chalcopyrite (5–10 per cent.). The sulphides are scattered throughout the central calcitic zone, and are not common in the diopside zone. They are absent from the hornblende zone. A feature of the sulphide-bearing veins is that the hornblende zone (hornblendite) is very prominent, sometimes comprising between one half and one third of the total width of the metasomatic body. The hornblendite has coarse decussate texture with the hornblende crystals averaging about 5 mm. in length. The pyroxenite has coarse granular texture with the average size of cross section of diopside crystals about 6 mm. (Plate 1, fig. 4).

CONCLUSIONS.

The variable thickness of the zone of hornblendite, the absence of grossularite from some veins, and sulphides from others suggest that metasomatizing solutions of variable composition have been active in the area. Some calcium-rich impregnations, for instance, may have been more aluminous than others, and as such allowed the formation of grossularite. A similar result, however, could be obtained if from some rocks alumina was leached more readily than from others. The importance of sulphides in certain veins suggests that some calcium-rich impregnations were not only rich in carbon, but also in sulphur. The variable thickness of the zone of hornblendite may be due to a variable capacity of the country rocks to " fix " those components expelled during calcium metasomatism.

It is significant that in the Nevoria area the diopsidic and hornblendic veins described in this paper have been developed through the activity of calcium-rich impregnations in which carbon dioxide was an important constituent. At the grade of metamorphism (amphibolite facies) at which this metasomatism took place calcite is apparently stable only when the impregnation by calcium has developed in an environment very rich in calcium.

Not only has introduction of calcium caused formation of metasomatic diopside, grossularite, calcite, etc., but it has caused expulsion of iron and magnesium into the surrounding rocks where they have been largely fixed as metasomatic hornblende. The expulsion of this iron and magnesium has caused, in turn, expulsion of small amounts of calcium and alkalies. This is deduced from the presence of calcic rims on the plagioclases in the actinolite schist immediately outside the zone of hornblende enrichment, and bluish tips on the amphiboles in the schists still further away from the centre of metasomatism. There is thus petrographic evidence of the importance in this area of miniature basic fronts and secondary alkali fronts not unlike some of those postulated by Reynolds as resulting from granitization in the Newry Complex, Ireland. (Reynolds, 1944, Fig. 5 on p. 235).

The answer to the problem of the source of the calcium is not easy. It is suggested, however, that the calcium was expelled from basic lavas and sediments during alkali metasomatism which lead to the formation of the abundant granitic rocks nearby. Thin sections of these granitic rocks often show partly corroded plagioclase relicts enclosed in microcline. Thus there is evidence of a vigorous alkali metasomatic corrosion of the plagioclases. Since the calcium, which has obviously been liberated in this process, cannot be accounted for in the minerals of the granitic rocks associated with the microcline paragenesis, it seems that this may be the source of the calcium for the metasomatic phenomena described in this paper.

In areas where original bedding planes of sediments or original basic lava flows are almost obliterated by regional metamorphism (as in the Southern Cross, Ravensthorpe and other goldfields areas in Western Australia) there are zones of considerable linear extent in which diopsidization is prominent. These could be mistaken by the unwary for interbedded calcium-rich sediments. The reason for the pseudo-stratigraphic restriction of diopsidization to certain narrow belts in (apparently) homogeneous rock is not fully known. It is possible, however, that the distribution is related to stresses set up during regional metamorphism and granitization.

The significance of the phenomena here briefly described is that it shows that lenses and veins of pyroxenite and hornblendite may be developed by metasomatism. It is possible that further work may show that some of the lenses of hornblendite and pyroxenite so common in the granitic gneisses and mobilized granites of Western Australia are basified remnants of terrain now engulfed by an advanced front of alkali metasomatism.

ACKNOWLEDGMENTS.

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PLATE I.

Fig. 1.

Assemblage 1.—Metasomatic diopside in hornblende-plagioclase schist, showing transgression of schistosity in places. Hornblende enrichment at edges of diopside is present but not prominent. Diamond drill core (20 mm. diameter) at 656 feet in Bore 1B. Nevoria Gold Mine. U. of W.A. No. 33873. (Photo., H. T. Phillipps.)

Fig. 2.

Assemblage 2.—Metasomatic vein in hornblende-plagioclase schist comprising zones of diopside (white) and core of grossularite (grey) enclosed in selvage of hornblende (black). Some small calcitic replacements are visible on the right. Diamond drill core (30 mm. diameter) at 751 feet in Bore 1C, Nevoria Gold Mine. U. of W.A. No. 33874. (Photo., H. T. Phillipps.)

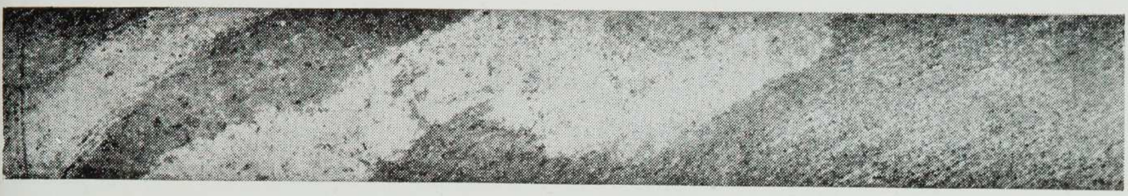
Fig. 3.

Assemblage 3.—Metasomatic vein in amphibole-plagioclase schist (left) comprising broad zones of hornblende (black) enclosing zones of diopside (grey) and core of calcite (white). Diamond drill core (28 mm. diameter) at 834 feet in Bore 4 Nevoria Gold Mine U. of W.A. No. 33875. (Photo., H. T. Phillipps.)

Fig. 4.

Assemblage 4.—Metasomatic vein in amphibole-plagioclase schist (with apparent dip in core of 30° to right). Vein comprises broad zones of hornblende (black) enclosing narrow zones of diopside (white) and core of mixture of calcite (light grey) and chalcopyrite and pyrrhotite (dark grey flecks). Relation of "basic front" of hornblendite to the calcium metasomatism is apparent. Diamond drill core (20 mm. diameter) at 781 feet in Bore 1B, Nevoria Gold Mine. U. of W.A. No. 33876. (Photo. H. T. Phillipps.)

PLATE I.



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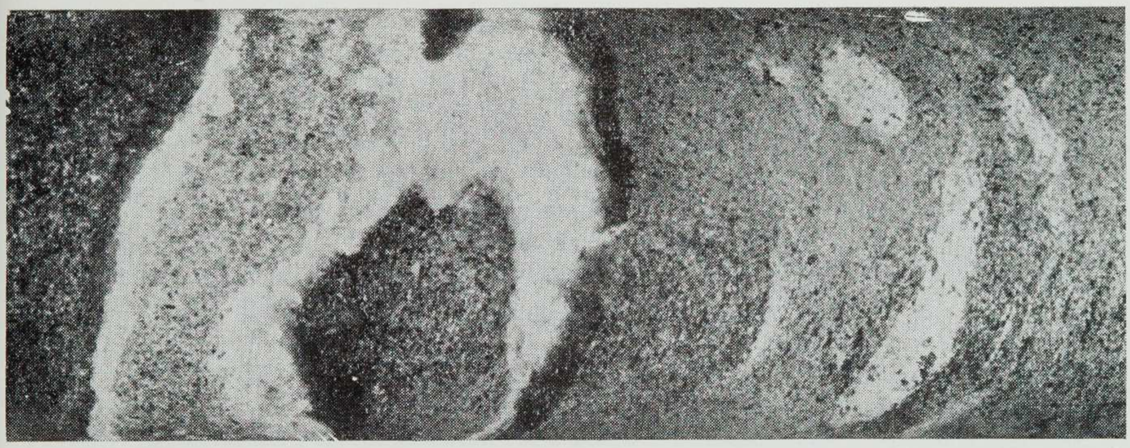

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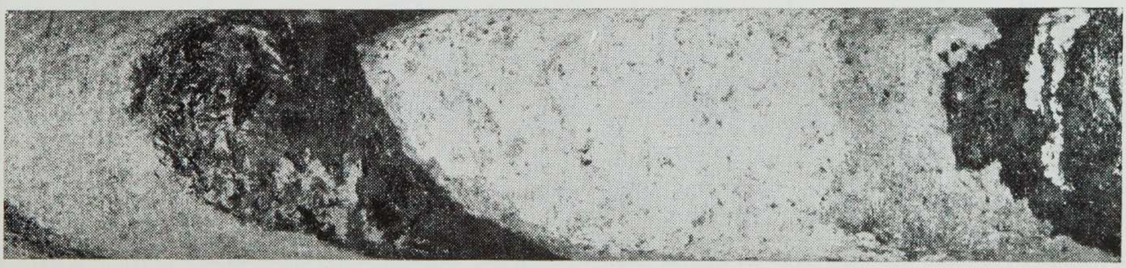

Fig. 3.

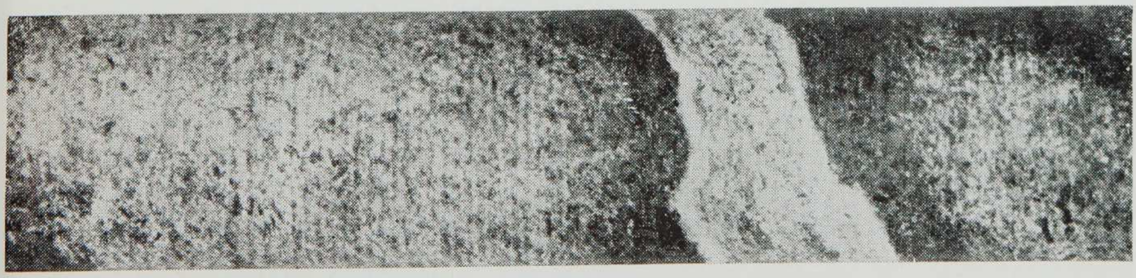

Fig. 4.